addition of lime to ponds has been used for some time to increase production. This follows the correlation found here with calcium and magnesium, both of which may be components of lime. Production often increases in ponds which remained dry for a season. This observation may be explained in part by the soil component found here to be most significantly correlated with production – nitrate nitrogen. Flooding of a soil brings about an accumulation of ammonia nitrogen that is released from soil organic matter and organic accumulations on pond bottoms. When ponds are drained and the soil becomes dry and aerated, ammonia nitrogen is converted to nitrate. The drying process also renders certain types of organic matter more susceptible to decomposition with subsequent release of nitrogen. All these factors increase the nitrate available in the soil.

There is a tendency for agricultural field plots to yield in a similar relative order from year to year. Why should this not be true of fish ponds? In fact, fish culturists claim that they can depend on one certain pond to produce better than another. This tendency of differences in yield or production to be permanent is often overlooked in experimental work. It would be unwise to conclude that factor "A" outproduced factor "B" unless the differences found were greater than those which might be expected from differences in the inherent productive capacities of the ponds. The time required for determining the uniformity of fish ponds is often prohibitive but may be alieviated by resorting to a soil test procedure. Testing for nitrate nitrogen is suggested from the preceeding results.

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POLYETHYLENE TUBES FOR STUDIES OF FERTILIZATION AND PRODUCTIVITY

By W. G. Klussmann and J. M. Inglis
Department of Wildlife Science
Texas A&M Universtiy, College Station

ABSTRACT

The purposes of this study were (1) to determine the feasibility of using isolated columns of water as an efficient way to obtain a natural series of similar bodies of water that are subject to identical climatic and environmental conditions, and (2) to determine the effect of fertilization and the fertilization rate that will give optimum and/or maximum phytoplankton production.

Twelve open-ended transparent polyethylene tubes 4' in diameter and 9' in length, were used to isolate vertical "transects" of water in the study pond. Measurements of oxygen, pH, water temperature, and turbidity were made to determine any physical or chemical changes which may have been attributable to the tubes.

The affect of fertilization was studied by applying three rates of single analysis of commercial fertilizer to the test tubes. The three experimental rates chosen were equivalent to 50, 100, and 150 pounds of 20-20-5 analysis fertilizer per surface acre of water. The C^{14} method of Goldman and Wetzel (1963) was used to determine the rate of carbon uptake by the phytoplankton.

The data revealed that the physical and chemical characteristics of the water within the tubes did not vary appreciably among the tubes or between the tubes and the open lake water. These uniform conditions prevailed within the test tubes for sufficient time to allow comparison of fertilized tests.

Of the three seasonal fertilization tests made, the response to the added nutrients was greatest in the spring. The highest carbon assimilation rate (300.1 mg C/m^3 per hour) occurred one week after fertilization in water fertilized at the 100 pounds per

surface acre equivalent. Generally, the data indicated that the greatest production occurred in the water of the test lake when fertilized in at the rate of 100 pounds per surface acre. Higher and lower rates of fertilization gave lower carbon assimilation values.

INTRODUCTION

Basic to all management of farm ponds for fishing is the development of adequate levels of primary productivity. This involves the maintenance of water fertility at levels that will support good stands of plankton that form the base of the food chain supporting fish populations.

Research in farm pond management has received little attention from state agencies and universities in Texas. Most pond management practices in Texas have therefore evolved from research conducted in other states or from random tests having no experimental design.

There are more than 200,000 private ponds in Texas. Most of these are managed to some degree to provide fishing (County Agents Annual Report, 1965). More than 75% of the requests for information from county agricultural agents and from the general public reaching the Extension Wildlife Specialist have to do with various aspects of pond management. In 1965, more than 10,000 pond owners requested assistance on pond management through the Texas Agricultural Extension Service. This increased interest of the citizens of Texas in fishing, fish production for private and commercial uses, and natural resources in general demands greater efficiency in fisheries management than is now possible.

It is known that fertilization increases the productivity of natural waters (Wiebe, 1935; Brown, 1951; Nelson and Edmondson, 1955) and that fish production varies directly with the phytoplankton population (Smith and Swingle, 1938, 1939, 1940). Such plankton organisms are the primary producers of a pond ecosystem (Lindeman, 1942). Along with the small amounts of detritus washed in from the watershed, plankton organisms form the base for all food chains, leading ultimately to pounds of fish in the system (Ryther, 1956; McConnel, 1963).

PURPOSE OF THE STUDY

The purpose of this study was to develop a practical technique and attendant methodology for determining the effect of fertility in terms of phytoplankton production caused by selected inorganic nutrients.

The study attempted (1) to determine the feasibility of using isolated columns of water as an efficient way to obtain a natural series of similar bodies of water that are subject to identical climatic and environmental conditions, (2) to determine the effect of fertilization and the fertilization rate that will give optimum and/or maximum phytoplankton production.

Data was collected to provide evidence for using isolated columns of water for basic limnological studies where replicated tests are needed and where numerous "identical" ponds are not available or feasible. The data also provided evidence needed to determine the amount of nutrients to be added to maximum and/or optimum primary production in waters on the Lufkin-Susquehanna soil types of Central Texas and provided the basis for future studies needed to determine the pounds of fish producible under a specific program of stocking and fertilization.

METHODS

The study was conducted at College Station in a pond located on Texas A&M University property. The pond was situated in the post oak belt area of Texas. The water in the pond was slightly basic with a mean pH of approximately 7.5 and a mean total salt content of 148 ppm. The pond impounded seventy-eight acre feet of water covering approximately seven surface acres. The soil type surrounding the impoundment was Lufkin-Susquehanna clay loam.

Twelve transparent, open-ended plastic tubes were used to isolate vertical "transects" of water in the pond. The tubes had a diameter of four feet and a length of seven feet (Figure 1B). The length provided for the isolation of a column of water six feet in height and for an extension of the tube one foot above the water's surface

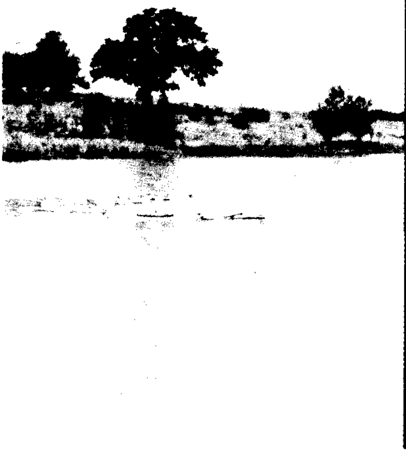


Figure 1A — Polyethylene test tubes positioned and anchored in lake.

Figure 1B — 4' x 7' Polyethylene test tubes used in productivity study.

to prevent inflow of water from wave action. The bottoms of the tubes were weighted to prevent water exchange around the bottom. The tubes were constructed from six mil. transparent polyethylene. Seams and hems were double-sewed with number eight nylon thread. Frames for the top and bottom were made from three-eight inch reinforcing steel bent into circular form. These steel rings provided the bottom weigth and the structure for attaching the floats and float frame. Floats were made by filling one-gallon plastic bottles with styrofoam. These floats gave sufficient bouyancy to suspend the ring with attached tube about six inches above the surface of the water. The floats were attached to an X-frame constructed from five-foot-long one-by-two pine boards. The floats attached at the ends of the boards suspended the top of each tube evenly above the water. The lower open end of the tube allowed for the inclusion of a portion of the pond bottom within the isolated column of water. The tubes were placed in the lake in a line along the six-foot depth profile in a location within the pond having the correct depth and a level, smooth bottom (Figure 1A).

Before the fertilization experiments were initiated, preliminary measurements of dissolved oxygen, pH, water temperature, and turbidity were taken of the water within the tubes for comparison to the same measurements taken of the lake water proper. These measurements were repeated daily for three days and weekly for three weeks to determine any physical or chemical changes which may have been attributable to the tubes.

Swingle and Smith (1938) have shown that nitrogen and phosphorus are essential in phytoplankton production and are normally used in large amounts. Potassium is also needed in moderate amounts. Three different rates of a single kind or analysis of commercial fertilizer were compared in three replications involving a total of nine tubes. Three untreated tubes were used as controls. The sources of the nutrients blended in the fertilizer were: 33.5% ammonium nitrate carried on diatomaceous earth, 46% phosphoric acid carried on a sand filler, and 62% muriate of potash (KCL).

The standard recommendation of the Texas Agricultural Extension Service is 100 pounds of 20-20-5 fertilizer per surface acre of water for the initial treatment (Klussmann, 1964). The three experimental rates chosen were 50, 100, and 150 pounds per surface acre of water.

The C^{14} method (Steeman-Nielsen and Hansen, 1959; Goldman and Wetzel, 1963) was selected to determine the rate of carbon up-take (productivity) by the phytoplankton. Weekly post-application measurements of gross productivity were made to determine the extent and duration of fertilizer effect on the water.

Three water samples of 250 milliliters each were taken from each tube in 250 milliliter B. O. D. bottles at a constant depth of six inches. Two of the three B. O. D. bottles were of clear glass and naturally transparent. The third B. O. D. bottle was "dark" to avoid penetration of sunlight. The dark bottle was prepared by painting the outside with a flat black lacquer, followed by taping completely with black plastic tape. Four microcuries of c^{14} carried in one ampoule of sodium bicarbonate solution was introduced into each bottle. The samples were incubated for four hours during midday.

Following incubation, 100 milliliters of each sample was filtered through a 47 mm. diameter, type SS millipore filter (3 aperture) and washed with 20 milliliters of 0.05 N HC1 to remove the free carbon. The filters were dried in a glass desiccator containing anhydrous $CaSO_4$ as the drying agent. The filters were attached to aluminum planchets with ordinary stop-cock grease and then counted in a Beckman low-beta proportional counter having a very thin window and a 27% efficiency for C^{14}.

The formula of Strickland (1960) was used to calculate the carbon taken up by the photosynthesis. This formula as used is given below:

$$\text{mg C/m}^3 = 1.05\frac{Y}{Z}W$$

Where: 1.05 equals correction for isotope discrimination.

Y equals counts per minute of light bottle filter pad minus counts per minute of dark bottle filter pad.

Z equals total counts per minute of the radioactive solution added to the light bottle (or dark bottle).

W equals total carbonate of sample in mg C/m^3.

Basic limnological measurements were taken from each tube during the C^{14} incubation period. The measurements included dissolved oxygen, pH, air and water temperature, free carbon dioxide, and Secchi disc turbidity.

In order to facilitate correlation of the effect of natural variation of water temperature with plankton productivity, each series of treatment-tests was repeated in January, May, and August. A fourth series initially scheduled for October was not conducted because of destruction of the plastic test tubes by a summer wind storm.

RESULTS

Before initiating the fertilization tests it was necessary to establish that the tube system represented a static physical and chemical environment similar to the lake proper and that the characteristics did not vary significantly among the tubes. Eight tubes of the type to be used in the fertilization tests were placed in the lake October 6, 1964. Measurements of dissolved oxygen, water temperature, pH, and Secchi disc turbidity were taken at midday on the third, sixth, seventh, and thirteenth day following placement in the lake. Oxygen and temperature measurements were taken at water depths of one, three, and five feet; pH measurements were taken only at the one-foot depth.

The data obtained from this series of measurements indicated little variation in these factors due to isolation of water within the tubes. The standard deviation for the dissolved oxygen among the tubes was 0.18 ppm or less during each series of measurements. The mean difference of dissolved oxygen between the tubes and the lake water was less than 0.20 ppm within each series of measurements. Further statistical tests were not employed since it was evident from the similarity of the dissolved oxygen measurements that the effect of oxygen differences among the tubes was negligible. As would be anticipated, the water temperature did not vary appreciably among the tubes or between the tubes and the lake.

Table 1 gives mean values of all measurements at the one-foot depth. Except for an expected gradual decline in oxygen and temperature at the three and five feet depths, homogeneity of the measured characteristics was evident at the three and five feet depths. The standard deviation of pH among the tubes was 0.04 or less in each of the four measurement series. The means of the pH values between the tubes and the lake varied 0.05 or less in each series of measurements. The pH readings are limited by the accuracy of the method of determination. In this case, the pH meter used (Beckman Model 180) does not generally give an accuracy greater than 0.1. Therefore, variation greater than the above could have resulted from mechanical error alone.

TABLE 1.

Comparison of mean values of dissolved O_2 temperature, and pH of isolated water contained in plastic tubes with surrounding lake water.

	Days After	*Dissolved O_2 ppm*		*Temperature, °C*		*pH*	
Measurement Series	*Placement of Tubes in Lake*	*Within Tubes*	*Within Lake*	*Within Tubes*	*Within Lake*	*Within Tubes*	*Within Lake*
1	3	8.22	8.07	20.4	20.8	7.62	7.66
2	6	8.91	9.06	23.5	23.7	7.41	7.36
3	7	8.62	8.86	21.6	21.6	7.45	7.46
4	13	11.64	11.62	19.0	19.0	7.66	7.66

Secchi disc measurements of turbidity were consistent around a depth of eight inches within and outside of the tubes. There was no other apparent visual change in the water isolated within the plastic tubes. This evidence of uniform conditions within the tubes as compared to the lake indicated that tubes could be satisfactorily used to represent a micro-community within the larger lake for the fertilization-productivity studies.

A seasonal series of fertilization-productivity test was carried out. Each fertilization-productivity test was repeated in winter, spring, and summer.

Winter Test

The first test (of fertilization-productivity relationships) was made during January and February, 1965. Twelve tubes were placed in the lake on January 21. On January 24, the fertilizer was applied to the water within the tubes. Random selection of tubes to be treated with each fertilization was made. Each rate was replicated in three tubes. Three unfertilized tubes served as controls. Equivalent amounts of 50, 100, and 150 pounds per surface acre of a 20-20-5 analysis of fertilizer was applied to the tubes (Table 2). The fertilizer was dissolved in a bottle of lake water and poured into randomly selected tubes.

TABLE 2.

Fertilization rates, amount applied to tubes and surface acre equivalents.

Rate Disignation	*Amount Applied To Tube*	*Equivalent Amount Per Surface Acre*
Rate 1	3.9 gms ammonium nitrate 2.9 gms phosphoric acid 0.53 gms muriate of potash	50 lbs. of 20-20-5 analysis
Rate 2	7.8 gms ammonium nitrate 5.7 gms phosphoric acid 1.1 gms muriate of potash	100 lbs. of 20-20-5 analysis
Rate 3	11.7 gms ammonium nitrate 10.2 gms phosphoric acid 1.7 gms muriate of potash	150 lbs. of 20-20-5 analysis

Carbon^{14} tests to determine the photosynthetic rate of phytoplankters were made on January 31, 1965, one week after introduction of the fertilizer, and on February 13, 1965, three weeks after fertilization.

Since water temperatures varied between 10 and 12.5 degrees, productivity was low. One week after fertilization, productivity in the fertilized tubes varied from 9.1 to 10.1 mg C/m^3 per hour during the winter test with the mean productivity of the control tubes being 6.9 mg C/m^3 per hour. Assimilation values indicate a slight increase in productivity in fertilized tubes; however, when compared to productivity in spring and summer, the increase due to fertilization was not appreciable (Figures 2 through 4).

Spring Test

The second fertilization-productivity test was made during May and June, 1965. The tubes were removed from the water after the winter test, cleaned and stored until placement again in the lake on May 13, 1965. Random application of the three rates of fertilizer was made on May 16, 1965. The first C^{14} test was made one week after fertilization.

Response to the added nutrients was greatest during the spring test period. Fertilization rate 2, equivalent to 100 pounds of 20-20-5, showed the highest gross productivity, 300.1 mg C/m^3 per hour (Figure 3). However, this rate also showed the highest degree of variability in response to the added nutrients. It was not possible to indicate that the peak measured productivity actually represented the true peak productivity response to fertilization since the true peak may have occurred before or shortly after the C^{14} measurement was made. The data were sufficient to indicate that the peak response to fertilization did occur during the first fourteen days. Later work indicates that the peak should have occurred six to twelve days after fertilization.

The lowest rate of fertilization, 50 pounds per surface acre equivalent, gave a higher rate of productivity than did the highest rate, 150 pounds per surface acre equivalent. Although these data were not conclusive, they did indicate that the optimum amount of fertilizer to be added for peak phytoplankton production occurred within the limits of 50 to 150 pounds per surface acre.

A definite phytoplankton bloom was visible in three tubes, two of which were fertilized at the 100-pound rate and one at the 50-pound rate. The bloom appeared about seven days after fertilization and remained visible for about a week. After disappearance of the visible bloom, Secchi disc measurements increased to approximately fourteen inches in the above tubes compared to about ten inches in other tubes indicating the clearing effect plankton blooms.

The productivity pulse resultant from the added nutrients disappeared by the end of the fourth week after fertilization. It is interesting to note that the productivity of the fertilized tubes dropped below that of the control of unfertilized tubes after culmination of the productivity pulse.

Summer Test

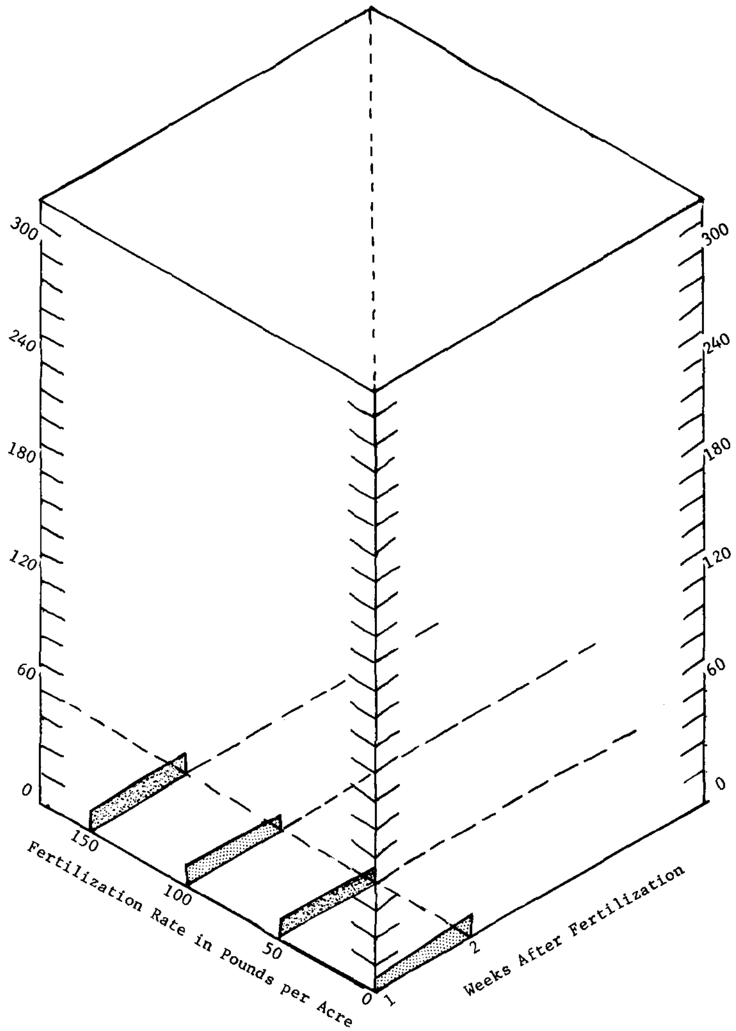
The summer test period was begun on August 17, 1965, with placement of the tubes in the lake. Fertilizer was added to the randomly selected tubes on August 20, 1965. Carbon^{14} tests were made on August 27 and September 3, 1965. A wind and hail storm destroyed all of the plastic tubes on September 5, 1965, by severing the float ring from the tube body thus allowing water exchange and sinking of the tubes.

Data obtained during the summer test generally support the hypothesis that primary productivity can be increased by adding essential nutrients. However, only the intermediate rate of fertilization (100 lbs./acre) gave a C^{14} uptake measure that was appreciably above the productivity of the unfertilized water. The mean values for C^{14} uptake of fertilization rates of 50 and 150 pounds per acre were not significantly different from control or nonfertilized water (Figure 4).

Generally, the response to fertilization was somewhat lower during the summer test than during the spring. However, the productivity in the control tubes was much greater than during the winter or spring tests.

FIGURE 2

WINTER FERTILIZATION TEST PERIOD, DIAGRAMMATIC COMPARISON OF FERTILIZATION RATE, TIME AND MEAN VALUES OF C^{14} ASSIMILATION

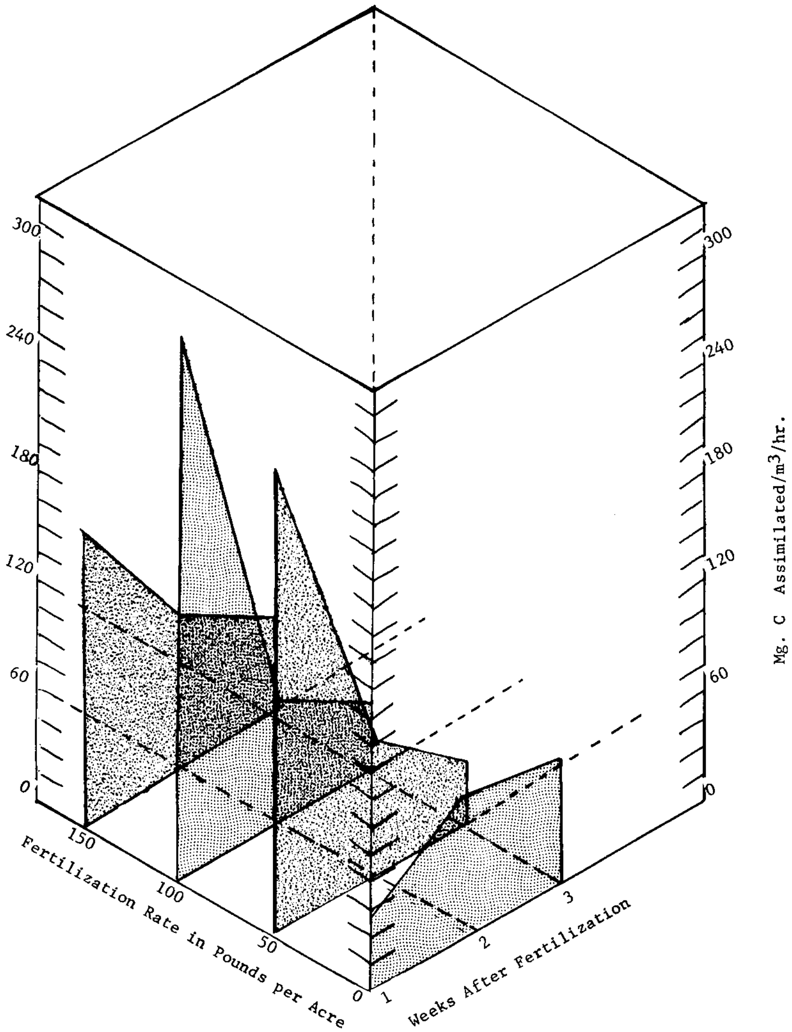


DISCUSSION

The basic purposes of the study were: (1) to determine the feasibility of the methodology, and (2) to determine the effect of fertilization on phytoplankton production.

FIGURE 3

SPRING FERTILIZATION TEST PERIOD, DIAGRAMMATIC COMPARISON OF FERTILIZATION RATE, TIME AND MEAN VALUES OF C^{14} ASSIMILATION

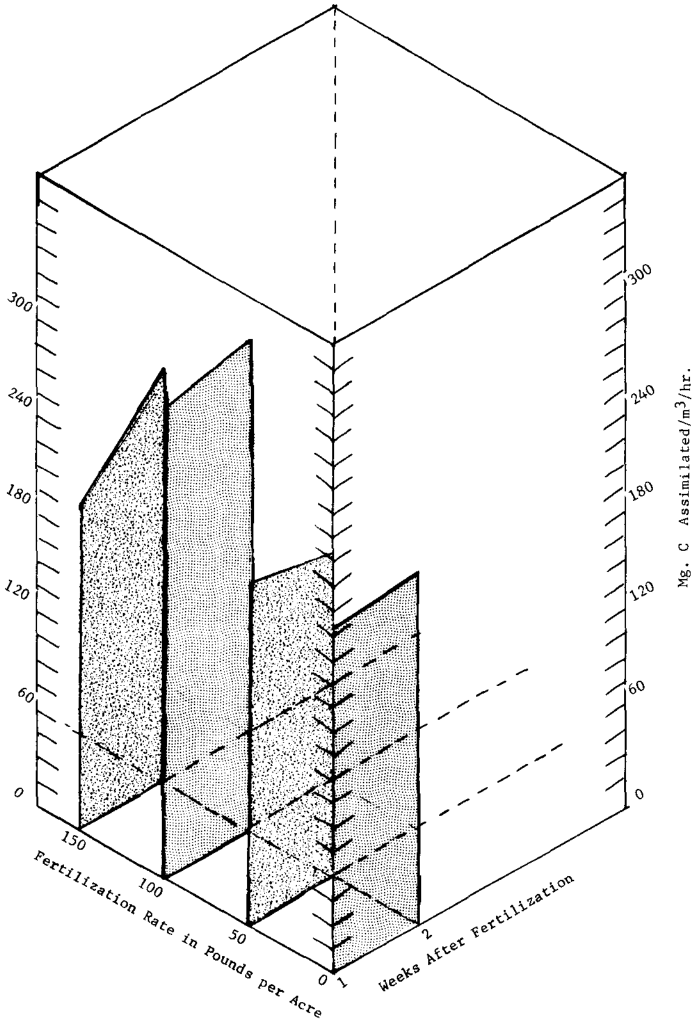


FEASIBILITY OF METHOD

A primary objective of this study was to determine the feasibility of using isolated columns of water as an efficient way to obtain a natural series of similar bodies of water that are subject to identical climatic and environmental conditions. The data indicate that use of large transparent polyethylene does offer a feasible solution for

FIGURE 4

SUMMER FERTILIZATION TEST PERIOD, DIAGRAMMATIC COMPARISON OF FERTILIZATION RATE, TIME AND MEAN VALUES OF C^{14} ASSIMILATION



replication of basic limnological studies where numerous ponds are not available or practical. Physical and chemical tests among the tubes and in comparison with the lake water revealed a comparable environment.

Several tubes had to be repaired with polyethylene tape as a result of deterioration in the upper part of the tube which was exposed to direct sunlight. Thus, for experiments which are to continue for a year or more, it would be essential to protect the tubes from direct sunlight. This could be done by covering in place during non-testing periods or by removing from the water and storing in a dark place.

Dense growths of periphyton appeared on all tubes about two to three weeks after placement in the water. Therefore, it was probably essential that all proposed tests should have been initiated within a short time after placement of the tubes in the water. It was necessary to clean the periphyton from the tubes before beginning fertilization or other tests in which the presence of periphyton might affect the results. Periphyton can be removed more readily immediately after taking the tubes from the water before drying. Spraying with ordinary hose and city water pressure is usually effective in removing most forms of periphyton.

The tubes must be thoroughly anchored to prevent movement by wind. The twelve tubes used in this experiment were anchored with six 12-pound window weights placed two on each end and one on each side. This anchoring technique failed to hold the tubes when they were destroyed in the windstorm on September 5, 1965. Exchange of water around the bottom of the tubes can be prevented by pressing the end support into the bottom soil.

PRODUCTION STUDIES

The second objective was to determine the effect of fertilization and the rate of fertilization that will yield optimum and/or maximum phytoplankton density. Although the number of fertilization tests and C^{14} assimilation analyses were limited, data indicate an optimum assimilation of carbon by phytoplankton in the water of the test lake occurred when fertilized at approximately 100 pounds per surface acre. Response to the added nutrients was greatest in the spring test. The winter test showed little response to added nutrients and a very low rate of productivity in both the fertilized and unfertilized tubes.

The summer test showed a rather high base productivity in fertilized and unfertilized tubes. There was little difference between the control (unfertilized) tubes and fertilization rates of 50 and 150 pounds per acre. The 100 pound per acre fertilization rate increased carbon assimilation by approximately 75 mg/m^3 per hour or about 30% above controls and other fertilization rates.

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A COMPARISON OF FISH POPULATION SAMPLING TECHNIQUES ON LAKE RAYMOND GARY, OKLAHOMA[1 2]

By Charles D. Bennett and Bradford E. Brown[3]
Oklahoma Department of Wildlife Conservation

ABSTRACT

Five types of fish population sampling gear were intensively fished in a 263 acre Oklahoma reservoir. The relative species compositions are compared, both between and within sampling methods and with bag seine samples taken at draining.

A method using accumulative percentages for determining the length of time necessary to sample a population with specific gear to estimate species composition is described.

Bated and unbaited nets had similar catch rates and species composition. Bluegill were more vulnerable to seine hauling during daylight hours than seine hauling at night. Gill nets failed to produce sufficient numbers of fish for statistical analysis, but larger mesh sizes captured flathead catfish and freshwater drum missed by most of the other types of gear. Small mesh gill nets revealed essentially the same species composition as rotenone and shocker samples. Trap nets caught white crappie in greater proportion than their numbers in the population. Shocker collections exhibited nocturnal increases in catch rates of redear sunfish, but not of bluegill, warmouth, or largemouth bass.

INTRODUCTION

A planned drawdown of Raymond Gary Lake, Oklahoma, provided an unusual opportunity to evaluate selectivity of gear used to sample reservoir fish populations. From March to August, 1967, intensive samples were taken with a variety of gear and the results compared with bag seine samples taken during draining.

General lake surveys are conducted by fishery biologists to obtain basic data from which management recommendations can be drawn. Reliable data can provide the basis for opening dates, restriction or liberalization of creels, correction of fish population imbalance, and needed research.

Some state and federal agencies have standard procedures for general fish population surveys and further standard procedures for interpreting data collected. In Oklahoma, standardization is limited to sampling gear. It is not known to what extent data is duplicated within the types of gear utilized. This report is intended to point out where overlapping of data occured in this study and suggests a method to determine the length of time necessary to sample a population with specific gear to estimate species composition. Also, it is hoped these data will be helpful in establishing standard lake sampling procedures in Oklahoma.

[1]Prepared for presentation to the 22nd Annual Meeting of the Southern Division, American Fisheries Society, Baltimore, Maryland.
[2]Prepared as part of a Federal Aid in Sport Fish Restoration Project, F-23-1.
[3]Assistant Unit Leader of the Oklahoma Cooperative Fishery Unit, Oklahoma State University.